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NPG Report No. 1372

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A STUDY OF PLASTIC LINERS FOR
FRAGMENTATION CONTROL OF 3"/50 PROJECTILES MK 25-0



U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

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U. S. Naval Proving Ground
Dahlgren, Virginia

A Study of Plastic Liners for
Fragmentation Control of 3" / 50 Projectiles Mk 25-0
by

J. W. Gorman
Terminal Ballistics Department

NPG REPORT NO. 1372

Task Assignment No.
NPG-B-2c-35-1-55

13 May 1955

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ABSTRACT

Nine rounds of 3"/50 projectiles Mk 25-0 were loaded with Composition B and detonated in a sawdust recovery chamber for studies of mass distribution of fragments. Under study was a plastic liner furnished by Naval Ordnance Test Station, Inyokern, California designed to control the size of the fragments produced to 15.4 gram pieces approximately cubical in shape. Six of the above projectiles contained the liner, and three control projectiles did not.

The liners were considered moderately successful.

Three additional rounds were fired with liners to determine the fragment velocity characteristics. Maximum recorded velocity was 4260 ft/sec over 30°, with a median velocity of 3850 ft/sec, accurate within 5%.

FOREWORD

This is the 29th partial report on Methods of Fragmentation Control and the second partial report on Effectiveness of Plastic Liners for Fragmentation Control. This test was authorized by reference (a) and carried out under Task Assignment NPG-B-2c-35-1-55 in accordance with reference (b).

This report was reviewed by:

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INTRODUCTION

The Naval Proving Ground has been conducting a study of various methods of controlling fragmentation and the limitations imposed upon their effectiveness by the size and shape toward which the control is aimed. This report covers a study of fluted plastic liners prepared by the Naval Ordnance Test Station and used to line projectiles before loading. The liner is designed to shape the explosive in such a way as to cut the projectile into the desired shape and size fragments.

DESCRIPTION OF MATERIALS

The liners used in this test were designed to produce cube-like fragments of approximately 15.4 grams each. The liners were made of cellulose triacetate and were shaped to fit a 3"/50 projectile Mk 25-0 (Illuminating), which is shown in Figure 1. Figure 2 is the drawing from which the liner was prepared. The projectiles were cast loaded with Composition B and fuzed with a special fuze for static detonation, Figure 3. The Mk 25 projectile was used because the approximately uniform sidewall thickness and the cylindrical cavity simplified the design and installation problems to be met in the use of liners.

All the liners were prepared at the Naval Ordnance Test Station. Some of the projectiles were loaded at the Naval Ordnance Test Station, and the remainder at the Naval Ordnance Laboratory.

PROCEDURE

Each projectile was placed in a cane fiberboard box 2' x 2' x 2', buried in sawdust in a steel chamber, and detonated. Fragments were recovered from the sawdust by means of a 1/4" mesh screen and a magnetic separator. Recovered fragments were divided into weight groups and photographed. Three lined projectiles loaded at Naval Ordnance Test Station, three loaded at Naval Ordnance Laboratory, and three unlined projectiles (to determine the "natural" mass distribution) were treated in this manner.

Three additional rounds with plastic liners, loaded at the Naval Ordnance Test Station, were placed vertically at the center of a 30' arena. This arena had 1-1/4" steel plates 15" high on its circumference in longitudinal zones 350° to 50° and 123° to 183°. Detonation of the projectiles and the fragment impacts on the plates were photographed with a 35mm Fastax camera at 2700 frames/second to obtain fragment velocity data.

RESULTS AND DISCUSSION

The photographs, Figures 4 through 12, show the recovered fragments and the detailed data on their numbers and weights. A summary of the weight data, given in the table below, shows the difference between the natural mass distribution and the controlled distribution for each of the two types. It is evident that the introduction of the liner has resulted in a considerable reduction of the number of fragments below about 10 grams in weight, and a corresponding increase above. The increase amounts to about 1400 grams, and its distribution is centered at about 13.5 grams for both types. The liners which were loaded at the Naval Ordnance Test Station tended to produce slightly heavier fragments, but this is of doubtful significance. The total weight of the controlled portion of the projectile is 2670 grams, and the design weight of fragments is 15.4 grams.

Detailed fragment velocity data are given in Tables 1, 2 and 3 of Appendix (C). Median velocities for the three rounds were 3800, 3850 and 3880 ft/sec, and the maximum velocity recorded was 4260 ft/sec \pm 100 ft/sec.

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TOTAL WEIGHTS OF RECOVERED FRAGMENTS IN GRAMS

(Three-Round Averages)

3"/50 Mk 25-0
Composition B Loaded

Weight Group	Natural	NOTS Liner NOL Loaded	NOTS Liner NOTS Loaded	NOL Loaded- Natural	NOTS Loaded- Natural
0	5/8	374	244	292	-130
5/8 -	1-1/4	290	136	174	-154
1-1/4 -	2-1/2	508	186	175	-322
2-1/2 -	3-1/2	311	77	86	-234
3-1/2 -	4-1/2	245	47	62	-198
4-1/2 -	5-1/2	159	35	45	-124
5-1/2 -	6-1/2	126	60	50	- 66
6-1/2 -	7-1/2	169	61	56	-108
7-1/2 -	8-1/2	163	95	99	- 68
8-1/2 -	9-1/2	107	108	96	1
9-1/2 -	10-1/2	96	110	117	14
10-1/2 -	11-1/2	134	236	117	102
11-1/2 -	12-1/2	111	289	274	178
12-1/2 -	13-1/2	68	441	456	373
13-1/2 -	14-1/2	97	321	442	224
14-1/2 -	15-1/2	89	190	199	101
15-1/2 -	16-1/2	32	149	111	117
16-1/2 -	17-1/2	56	85	80	29
17-1/2 -	18-1/2	36	42	66	6
18-1/2 -	19-1/2	19	38	76	19
19-1/2 +		321	562	502	241
Totals		3511	3512	3575	181

CONCLUSIONS

The liners were moderately successful in performing their intended function of controlling fragment size. Further study of this type is warranted, and possibilities of much improved performance are considered good.

REFERENCES

- (a) BUORD Conf ltr Re2c-JSM:ngh S78-1 Ser 70474
of 3 February 1954
- (b) BUORD Conf ltr NP9-Re2c-JSM:ngh Ser 81799
of 14 July 1954

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APPENDIX A

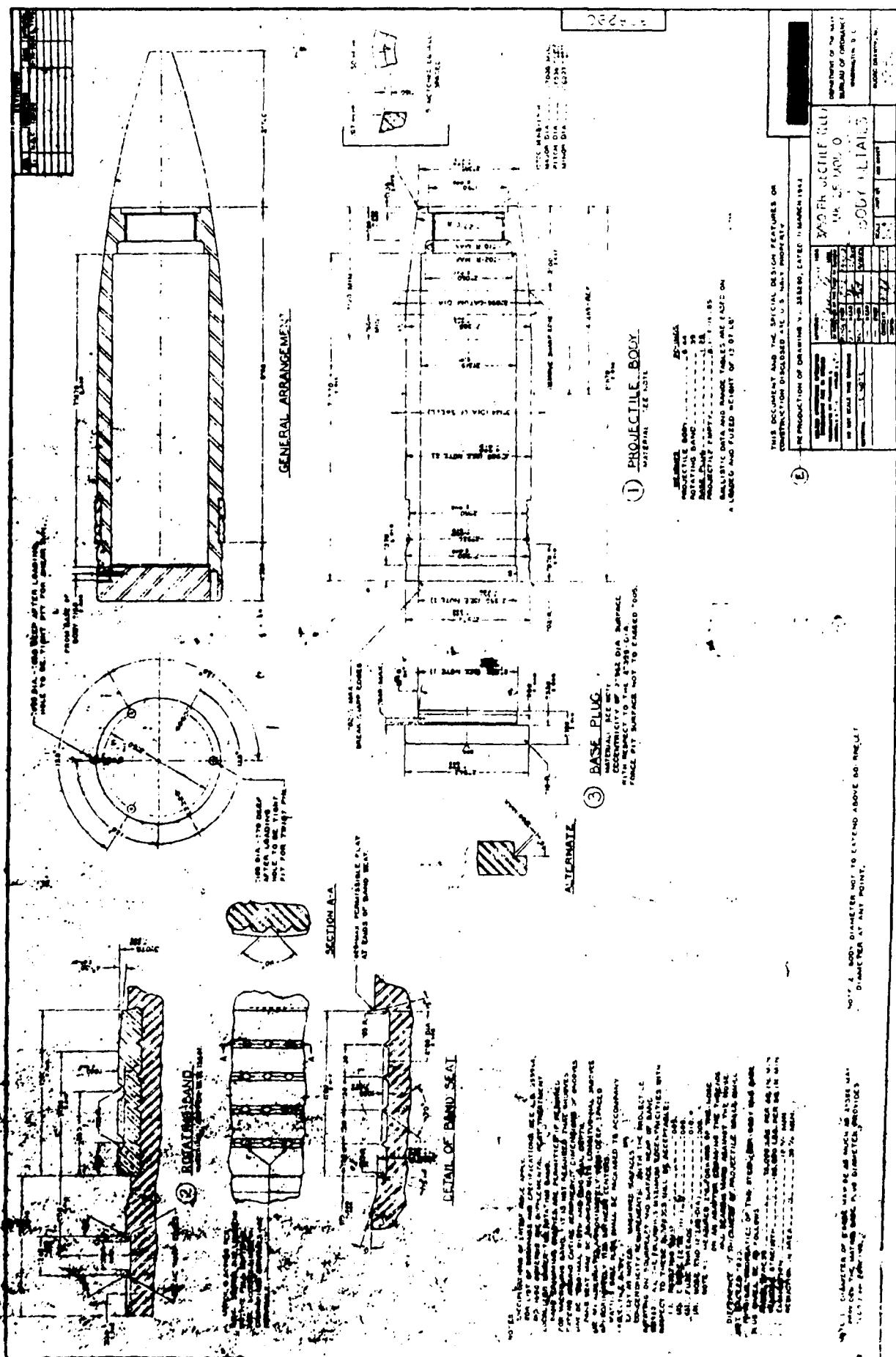


Figure 1

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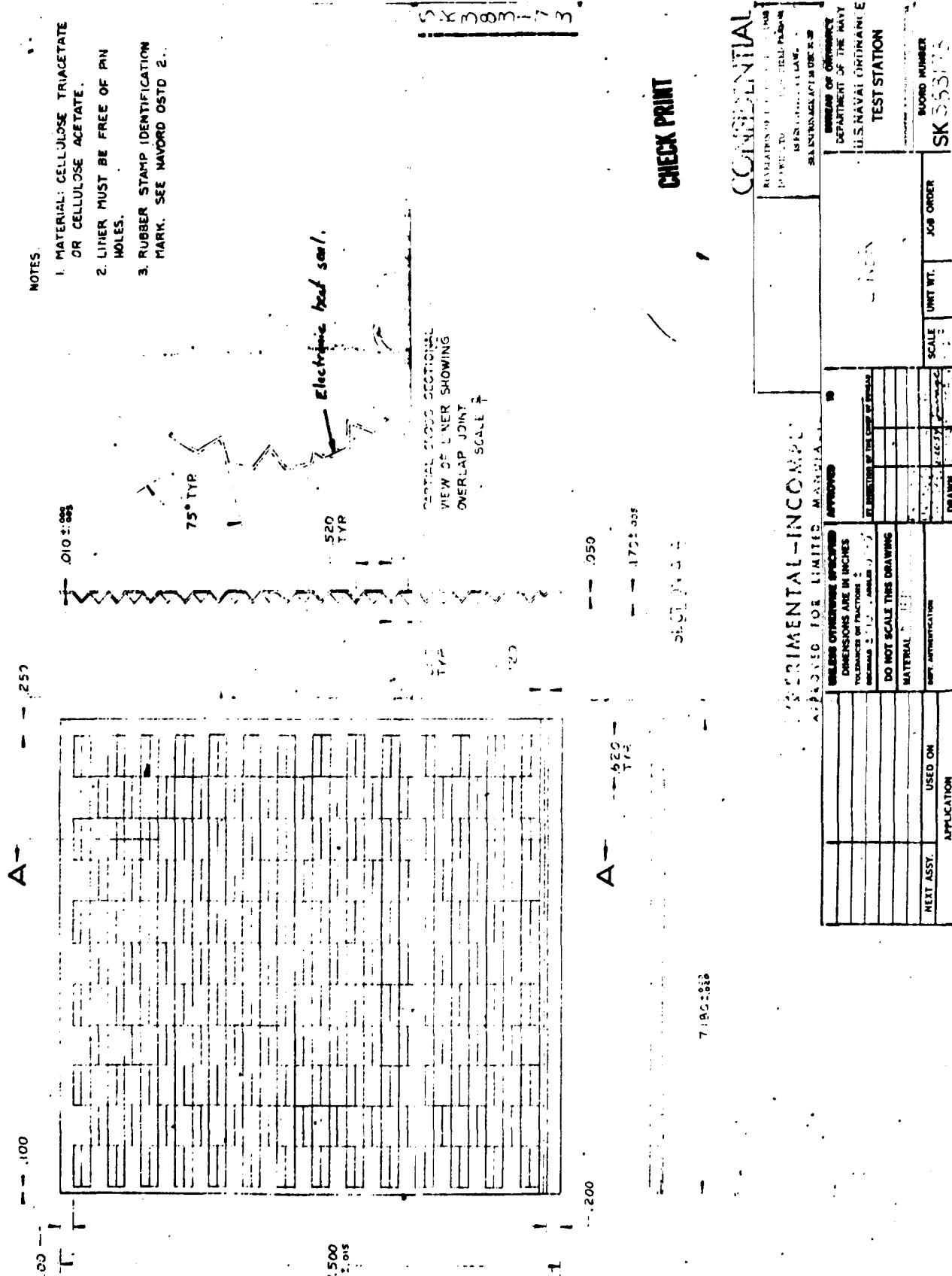
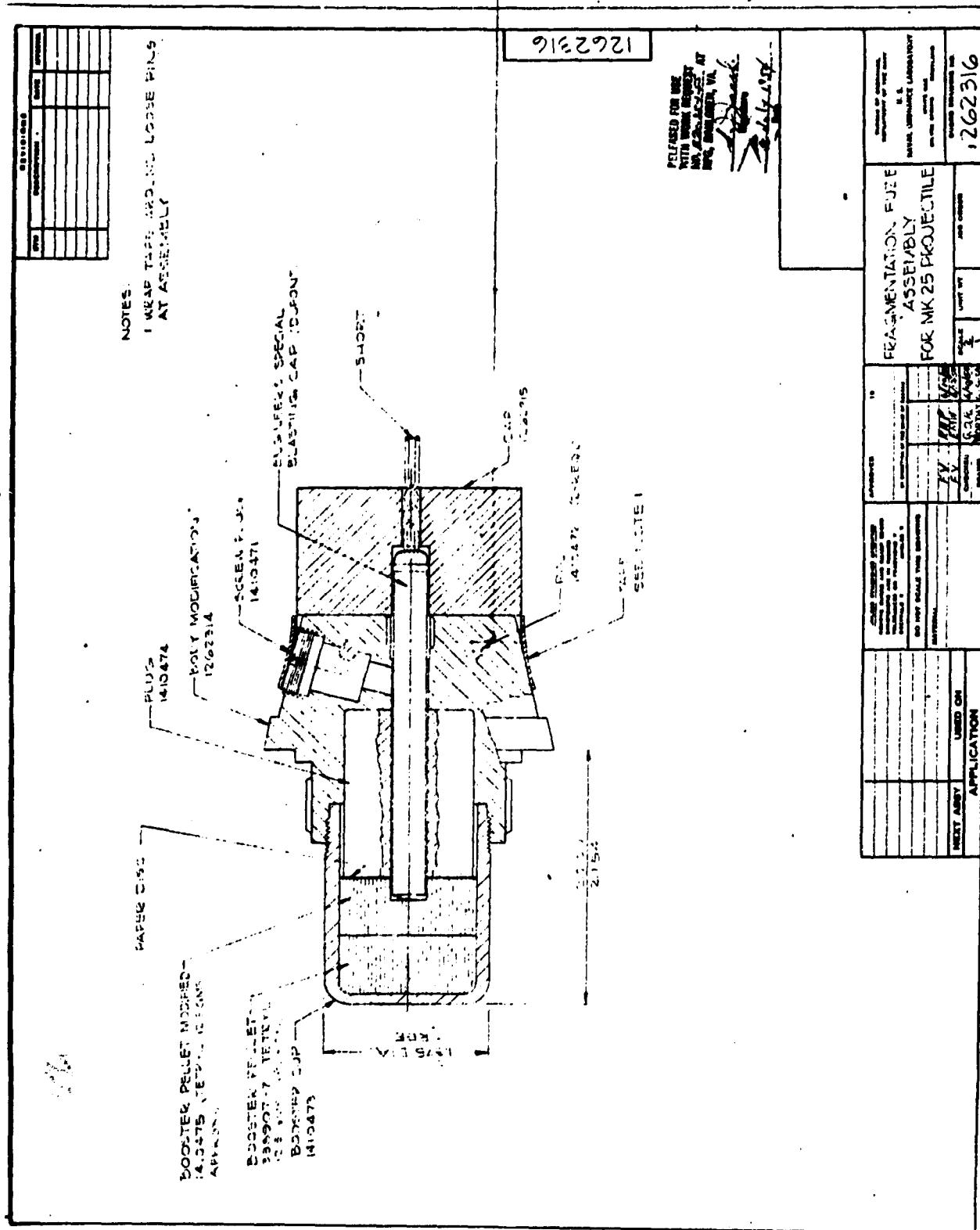


Figure 2

NP9-67299
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Plastic liner for fragmentation control of
3"/50 projectile Mk 25-0.

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Figure 3

NP9-67283 CONFIDENTIAL

Fuze for 3" /50 projectile Mk 25-O Composition B loaded with plastic liner.

APPENDIX B

FRAG. NO. 1856

N.P.9 NO. 66207

RD-NO. 4 NATURAL FRAGMENTATION 3/50 MK 25-1

0 - 5/8 GMS.
PCS.
369 GMS.

5/8 - 1 1/8 GMS.
342 PCS.
298 GMS.

1 1/8 - 2 1/8 GMS.
284 PCS.
498 GMS.

2 1/8 - 5 GMS.
174 PCS.
588 GMS.

5 - 10 GMS.
105 PCS.
738 GMS.

10 - 20 GMS.
50 PCS.
664 GMS.

20 - 40 GMS.
10 PCS.
260 GMS.

40 - 80 GMS.
2 PCS.
118 GMS.

FUZE-FRAGS.
93 PCS.
427 GMS.

SCALE 1"

Figure 4

NP9-66207
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Recovered fragments from unlined control 3" / 50
projectile Mk 25-0.

FRAG NO. 1857

RD-NO. 5 NATURAL FRAGMENTATION 3/50 MK.25-1

N.P.9 NO. 66208

0 - 5/8 GMS.
PCS.
391 GMS.

5/8 - 1 GMS.
325 PCS.
287 GMS.

1 - 2 GMS.
317 PCS.
556 GMS.

2 - 5 GMS.
179 PCS.
600 GMS.

5 - 10 GMS.
94 PCS.
660 GMS.

10 - 20 GMS.
55 PCS.
726 GMS.

20 - 40 GMS.
3 PCS.
74 GMS.
40 - 80 GMS.
1 PCS.
41 GMS.
80 - 160 GMS.
1 PCS.
134 GMS.

FUZE-FRAGS.
114 PCS.
435 GMS.



Figure 5

NP9-66208
CONFIDENTIAL

Recovered fragments from unlined control 3"/50
projectile Mk 25-0.

FRAG NO. 1859

0 - 5/8 GMS.
362 PCS.
GMS.

RD - NO. 6 NATURAL FRAGMENTATION 3/50 MK 25-1

N.P.9 NO. 66254

5/8 - 1/2 GMS.
326 PCS.
285 GMS.

1 1/2 - 2 GMS.
271 PCS.
470 GMS.

2 1/2 - 5 GMS.
201 PCS.
712 GMS.

5 - 10 GMS.
97 PCS.
684 GMS.

10 - 20 GMS.
58 PCS.
766 GMS.

20 - 40 GMS.
7 PCS.

157 GMS.

80 - 160 GMS.
101 PCS.

FUZE-FRAGS.
121 PCS.

438 GMS.

SCALE 1"

Figure 6

NP9-66254
CONFIDENTIAL

Recovered fragments from unlined control 3"/50
projectile Mk 25-0.

FRAG NO. 1848

PLASTIC LINER FOR FRAGMENTATION CONTROL 3/50 MK 25-1 RD. NO. 1

N.P.9 NO. 65944

0 - 5/8	GMS.
	PCS.
245.1	GMS.
5/8 - 1	GMS.
138	PCS.
120.8	GMS.
1 - 2	GMS.
95	PCS.
163.1	GMS.
212 - 3 1/2	GMS.
24	PCS.
70.0	GMS.
3 - 4	GMS.
11	PCS.
42.2	GMS.
4 - 5	GMS.
8	PCS.
39.4	GMS.
5 - 6	GMS.
11	PCS.
66.1	GMS.
6 - 7	GMS.
9	PCS.
62.3	GMS.
7 - 8	GMS.
10	PCS.
79.2	GMS.
8 - 9	GMS.
13	PCS.
116.2	GMS.
9 - 10	GMS.
8	PCS.
80.1	GMS.
10 - 11	GMS.
27	PCS.
298.4	GMS.
11 - 12	GMS.
25	PCS.
301.7	GMS.
12 - 13	GMS.
30	PCS.
389.9	GMS.
13 - 14	GMS.
22	PCS.
308.9	GMS.
14 - 15	GMS.
14	PCS.
209.3	GMS.
15 - 20	GMS.
19	PCS.
323.2	GMS.
20 +	GMS.
14	PCS.
584.0	GMS.
FUZE-FRAGS.	
66	PCS.
440.2	GMS.

SCALE 1"

Figure 7

NP9-65944
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Recovered fragments from 3"/50 projectile Mk 25
with Naval Ordnance Test Station liner loaded
at Naval Ordnance Laboratory.

FRAG NO. 1849

N.P.9 NO. 65993

PLASTIC LINER FOR FRAGMENTATION CONTROL 3/50 MK 25-1 RD - NO. 2

0 - 5/8 GMS. PCS.
258.2 GMS.
5/8 - 1/2 GMS. PCS.
1 7/9 GMS. PCS.
1 4 9/8 GMS. PCS.
1 1 - 2 GMS. PCS.
1 2 5/8 GMS. PCS.
2 1 8/6 GMS. PCS.
2 1/2 - 3 1/2 GMS. PCS.
3 0 GMS. PCS.
3 4 8/8 GMS. PCS.
3 1 - 4 GMS. PCS.
1 4 GMS. PCS.
5 3/7 GMS. PCS.
4 1 - 5 GMS. PCS.
6 GMS. PCS.
2 9/6 GMS. PCS.
5 2 - 6 GMS. PCS.
1 2 GMS. PCS.
7 2/1 GMS. PCS.
6 2 - 7 GMS. PCS.
1 3 GMS. PCS.
9 1/9 GMS. PCS.
7 2 - 8 GMS. PCS.
9 GMS. PCS.
7 1/3 GMS. PCS.
8 1 - 9 GMS. PCS.
1 5 GMS. PCS.
1 3 5/7 GMS. PCS.
9 10 GMS. PCS.
1 6 GMS. PCS.
1 5 9/6 GMS. PCS.
10 11 GMS. PCS.
1 7 GMS. PCS.
1 8 9/3 GMS. PCS.
11 12 GMS. PCS.
2 6 GMS. PCS.
3 1 0/6 GMS. PCS.
12 13 GMS. PCS.
4 2 GMS. PCS.
5 4 2/9 GMS. PCS.
13 14 GMS. PCS.
14 GMS. PCS.
14 15 GMS. PCS.
1 1 GMS. PCS.
1 6 5/1 GMS. PCS.
15 20 GMS. PCS.
1 7 GMS. PCS.
2 8 6/8 GMS. PCS.
20 GMS. PCS.
1 0 0 GMS. PCS.
4 9 1/1 GMS. PCS.
FUZE-FRAGS.
1 0 8 GMS. PCS.
4 5 4/8 GMS. PCS.

SCALE 1

Figure 8

NP9-65993
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Recovered fragments from 3"/50 projectile Mk 25
with Naval Ordnance Test Station liner loaded
at Naval Ordnance Laboratory.

FRAG. NO. 1851

PLASTIC LINER FOR FRAGMENTATION CONTROL 3/50 MK 25-1 RD - NO. 3

N.P.9 NO. 65996

0 - 5/8 GMS.

227.5 GMS.

5/8 - 1/4 GMS.

165 PCS.

136.9 GMS.

1/2 - 2 GMS.

103 PCS.

176.6 GMS.

2 1/2 - 3 1/4 GMS.

26 PCS.

75.2 GMS.

3 1/2 - 4 1/2 GMS.

12 PCS.

463 GMS.

4 1/2 - 5 GMS.

350 GMS.

5 1/2 - 6 GMS.

7 PCS.

41.2 GMS.

6 1/2 - 7 GMS.

4 PCS.

27.9 GMS.

7 1/2 - 8 GMS.

17 PCS.

134.0 GMS.

8 - 9 GMS.

8 PCS.

70.8 GMS.

9 - 10 GMS.

9 PCS.

91.4 GMS.

10 - 11 1/2 GMS.

20 PCS.

219.3 GMS.

11 - 12 GMS.

21 PCS.

255.6 GMS.

12 - 13 GMS.

30 PCS.

391.6 GMS.

13 - 14 GMS.

33 PCS.

460.0 GMS.

14 - 15 GMS.

13 PCS.

194.7 GMS.

15 - 20 GMS.

22 PCS.

370.1 GMS.

20 + GMS.

571.7 GMS.

FUZE-FRAGS.

73 PCS.

451.8 GMS.

SCALE

Figure 9

NP9-65996
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Recovered fragments from 3"/50 projectile Mk 25 with Naval Ordnance Test Station liner loaded at Naval Ordnance Laboratory.

FRAG NO. 1876

PLASTIC LINER FOR FRAGMENTATION CONTROL 3/50 MK 25-1 RD. NO. N.O.T.S - 1 N.P.9 NO. 66904

0 - 5% GMS.

PCS.

285.8 GMS.

58 - 1/4 GMS.

217 PCS.

183.8 GMS.

14 - 2 1/2 GMS.

95 PCS.

161.0 GMS.

2 1/2 - 3 1/2 GMS.

34 PCS.

98.5 GMS.

3 1/2 - 4 1/2 GMS.

22 PCS.

83.4 GMS.

4 1/2 - 5 GMS.

11 PCS.

55.5 GMS.

5 1/2 - 6 1/2 GMS.

7 PCS.

41.7 GMS.

6 1/2 - 7 GMS.

8 PCS.

55.3 GMS.

7 1/2 - 8 GMS.

13 PCS.

103.2 GMS.

8 - 9 GMS.

11 PCS.

97.4 GMS.

9 - 10 GMS.

14 PCS.

140.6 GMS.

10 - 11 1/2 GMS.

14 PCS.

154.4 GMS.

11 - 12 GMS.

18 PCS.

217.8 GMS.

12 - 13 GMS.

33 PCS.

431.3 GMS.

13 - 14 GMS.

32 PCS.

447.8 GMS.

14 - 15 GMS.

13 PCS.

193.4 GMS.

15 - 20 GMS.

21 PCS.

359.6 GMS.

20 + GMS.

11 PCS.

467.5 GMS.

FUZE-FRAGS.

166 PCS.

450.5 GMS.

SCALE

Figure 10

NP9-66904
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Recovered fragments from 3"/50 projectile Mk 25 with Naval Ordnance Test Station liner loaded at Naval Ordnance Test Station.

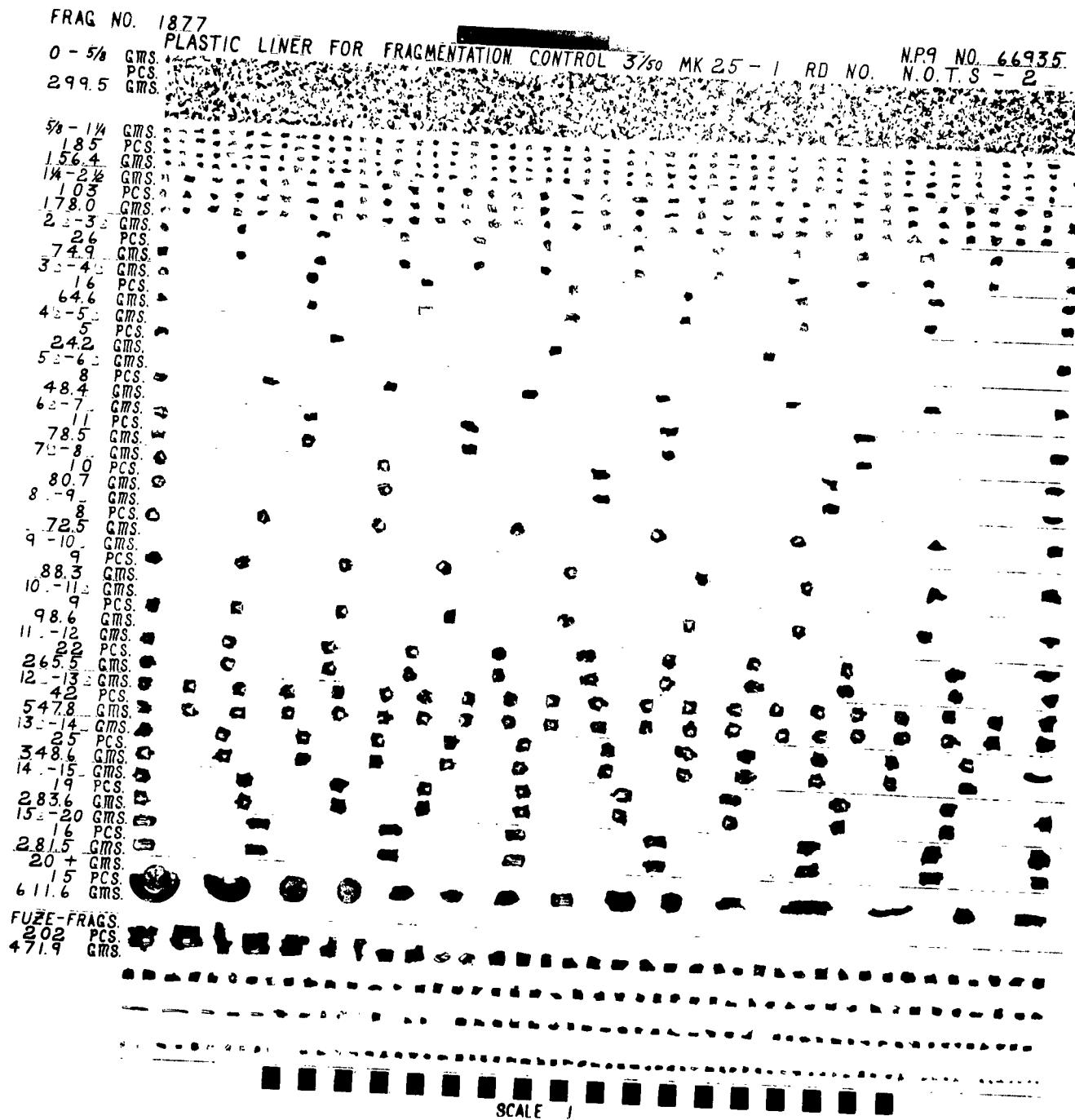


Figure 11

NP9-66935
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Recovered fragments from 3"/50 projectile Mk 25
 with Naval Ordnance Test Station liner loaded
 at Naval Ordnance Test Station.

FRAG NO. 1878

PLASTIC LINER FOR FRAGMENTATION CONTROL 3/50 MK 25 - 1 RD NO. N.O.T.S - 3

NP9 NO. 67037

0 - 5/8 GMS.

PCS.

317.4 GMS.

5/8 - 1/4 GMS.

PCS.

181.4 GMS.

PCS.

1/4 - 2 1/2 GMS.

PCS.

1/10 GMS.

PCS.

187.1 GMS.

PCS.

2 - 3 GMS.

PCS.

24 GMS.

PCS.

85.0 GMS.

PCS.

3 - 4 GMS.

PCS.

10 GMS.

PCS.

39.5 GMS.

PCS.

4 - 5 GMS.

PCS.

54.8 GMS.

PCS.

5 - 6 GMS.

PCS.

10 GMS.

PCS.

60.7 GMS.

PCS.

6 - 7 GMS.

PCS.

5 GMS.

PCS.

35.6 GMS.

PCS.

7 - 8 GMS.

PCS.

113.1 GMS.

PCS.

8 - 9 GMS.

PCS.

13 GMS.

PCS.

116.7 GMS.

PCS.

9 - 10 GMS.

PCS.

12 GMS.

PCS.

120.9 GMS.

PCS.

10 - 11 GMS.

PCS.

9 GMS.

PCS.

9 - 10 GMS.

PCS.

11 - 12 GMS.

PCS.

28 GMS.

PCS.

33.8.8 GMS.

PCS.

12 - 13 GMS.

PCS.

30 GMS.

PCS.

389.2 GMS.

PCS.

13 - 14 GMS.

PCS.

38 GMS.

PCS.

528.5 GMS.

PCS.

14 - 15 GMS.

PCS.

8 GMS.

PCS.

119.2 GMS.

PCS.

15 - 20 GMS.

PCS.

23 GMS.

PCS.

398.1 GMS.

PCS.

20 + GMS.

PCS.

385.8 GMS.

PCS.

FUZE-FRAGS.

183 PCS.

460.9 GMS.

SCALE 1

Figure 12

NP9-67037
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Recovered fragments from 3"/50 projectile Mk 25
with Naval Ordnance Test Station liner loaded
at Naval Ordnance Test Station.

APPENDIX C

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TABLE 1

FRAGMENT VELOCITY DATA

Date: 2 December 1954
30 Ft. Radius Arena
35mm Fastax Camera
Rd. No. 1 3"/50 Mk 25

2700 Frames per second
Filler Composition B

<u>Frame in Which Hit Occurred</u>	<u>No. Fragments</u>	<u>Velocity (f/s)</u>
20	18	4050
21	9	3860
22	12	3680
23	6	3520
24	4	3380
25	5	3240
26	2	3120
Median		3850
Average		3730

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TABLE 2

FRAGMENT VELOCITY DATA

Date: 2 December 1954 2700 Frames per second
30 Ft. Radius Arena Filler Composition B
35mm Fastax Camera
Rd. No. 2 3" / 50 Mk 25

<u>Frame in Which Hit Occurred</u>	<u>No. Fragments</u>	<u>Velocity (f/s)</u>
20	14	4050
21	13	3860
22	8	3680
23	6	3520
24	5	3380
25	9	3240
26	1	3120
Median		3800
Average		3690

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TABLE 3

FRAGMENT VELOCITY DATA

Date: 2 December 1954
30 Ft. Radius Arena
35mm Fastax Camera
Rd. No. 3 3"/50 Mk 25

2700 Frames per second
Filler Composition B

<u>Frame in Which Hit Occurred</u>	<u>No. Fragments</u>	<u>Velocity (f/s)</u>
19	7	4260
20	15	4050
21	11	3860
22	8	3680
23	3	3520
24	4	3380
25	6	3240
27	4	3000
28	1	2890
Median		3880
Average		3740

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